A Study of Ice-rafted Debris as a Paleoclimatic Proxy for the North Atlantic for the Last One Million Years.

Haack, M. The Ohio State University, Department of Geological Sciences, Columbus,OH 43210, haack.6@osu.edu
Krissek, L. The Ohio State University, Department of Geological Sciences, Columbus, OH 43210, krissek.1@osu.edu

Introduction

1

Interactions between the ocean, atmosphere, and glaciers play a major role in the earth's climate system. Previous studies have identified the North Atlantic as a region that is particularly sensitive to these climate interactions.

2

"Global Salt Conveyor"

In the North Atlantic,

- Warm suface water releases heat to the atmosphere
- Cooled surface water sinks
- Rates of inflow (cooling and sinking) have varied between glacial and interglacial episodes

Figure 1. *Diagram of the Global Thermohaline Circulation*

3

Milankovitch Theory

Three separate cyclic movements combine to produce variations in solar insolation received at the earth's surface.

1. *Precession of Earth's axis of rotation*
2. *Changes in tilt of axis (Obliquity)*
3. *Changes in the shape of Earth's orbit about the sun (Eccentricity)*

The changes in solar insolation are viewed as the "pacemaker" of the Pleistocene Ice Ages.

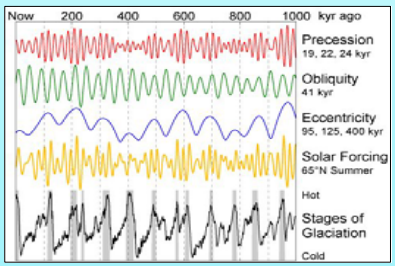

Figure 2. *Diagram of the Milankovitch or "Orbital" cycles which show variations in insolation during the last one million years, with a resulting history of glaciations and interglacials.*

4

Supply Rates of Ice-rafted Debris (IRD)

Influx of ice-rafted debris will vary with climate conditions. *For example,*

- Last interglacial (*Fig. 4a*)
- Last glacial maximum (*Fig. 4b*)

- Note the significant increase in IRD supply during glacial maximum.

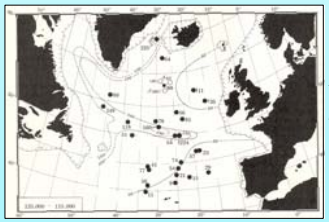

Figure 4a. *Mean rate of IRD deposition (mg / cm² / 1000 years) in the North Atlantic during an interglacial period. This pattern largely resembles modern paths of sea ice/icebergs. (Ruddiman, W.F., 1977)*

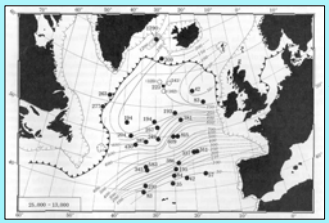

Figure 4b. *Mean rate of IRD deposition (mg / cm² / 1000 years) in the North Atlantic during glacial period. Line with triangles is ice-sheet limit on the continents and inferred ice limit over ocean. (Ruddiman, W.F., 1977)*

Background and Objectives

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IODP Expedition 303 to North Atlantic

- New sediment record from Site 1305 (*fig. 5a*) – *Eirik Drift*
- Examine Site 1305 sediment samples for IRD input over the last one million years

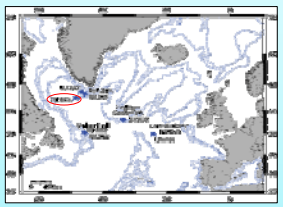

Figure 5a. *Map of IODP Expedition 303 Sites. Note the location of Site 1305 which will be examined in this study.*

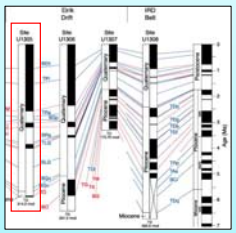

Figure 5b. *Schematic stratigraphy at the five sites drilled during Expedition 303. At Site 1305, three cores were drilled to yield a complete and continuous sediment record at this location. Note there are not significant time gaps within the record at Site 1305.*

Ice-rafted Debris is defined:

- as the weight percent in the > 150 µm fraction relative to the total sediment
- *later*, as the number of lithic grains per gram of sediment

Materials and Methods

6

In this study:

- ~ 380 samples will be examined
- estimated spacing of 3,000 – 4,000 years

To obtain data, each sample:

- is dried and weighed
- wet – sieved at 150 µm and 2mm
- dried and reweighed

Figure 6. *The interval shown contains the Heinrich 4 layer (H4), ~9 cm thick. The darker specks and/or disturbed parts of the core surface between 54 and 63 cm are indications of larger grains (i.e., IRD),which are dragged through the core as it's being split.*

Results

7

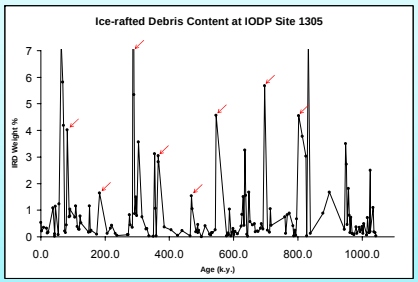

Figure 7. *Age versus IRD weight percentage plot for cores drilled at Site 1305. Note the red arrows show peaks that appear to record 100,000 year Eccentricity cycles.*

Conclusions

8

- Significant variations in IRD abundances are observed
- Largest peaks appear to record variations in IRD input at 100 k.y. period (Eccentricity). This indicates sensitivity of IRD input to general climate forcing. Other studies have shown similar dominance of 100 k.y. cycles since ~ 800,000 years ago.

Future work,

- Conclude laboratory work to fill in gaps in data set to observe shorter period Milankovitch cycles.
- Examining the grain composition of samples to identify to iceberg sources.

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